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ABSTRACT

In this paper, the status and structure of science education in the United States are reviewed and summarized in six major sections. These include: (1) an introduction (placing science education in the context of the school system as a whole and noting the government's role, administration and funding, school types, external examination policies, national plans, and pressures for reform); (2) aims and objectives of science education (identifying four categories of goals); (3) curriculum development and content (examining patterns found in science curriculum programs); (4) teacher education (reviewing the status of pre-service, pre-service science, and in-service science education); (5) science teaching (reporting on current teaching patterns, teaching methods, student assessment systems, supervisory practices, and professional science associations); and (6) other topics (describing the status of and/or practices related to laboratory facilities, equipment and materials, talented students, special groups, computers, and out-of-school science opportunities). Thirty-four footnotes are appended. (ML)

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THE UNITED STATES SCIENCE CURRICULUM CASE STUDY

Education in the United States is characterized by great variety. It is essentially decentralized with education policies made by each of the 50 states and sometimes by communities within these states. In most communities, children begin their education at the age of five or six. Almost all of the children and young people will continue their education through the school leaving age which is usually 16. However, most young people will continue their studies and finish the secondary school.

Historically, there has been a general commitment to providing education for everyone. In most states, communities are mandated to provide education for all children and young people.

Section 1: Introduction

1. System Structures

In the Constitution of the United States, the states retain all powers that were not specifically empowered to the federal government; among those powers deliberately withheld from federal control was that of providing education. To this day, most educational policies are directed through the 50 State Departments of Education or local county or district agencies. Of the entire 50 states, only the State of Hawaii has a uniform system throughout its various islands.

The standard three tiers into which education is grouped in the U.S. are: kindergarten through grade six; grades 7 through 9; and grades 10 though 12. Less commonly, some school systems are organized as elementary (K-8) and secondary (9-12). A third pattern is emerging with the elementary school encompassing grades 1 through 5, a middle school containing grades 6 through 8, and a high school with grades 9 through 12. Formal education usually begins in kindergarten or grade 1. Some states include guidelines for preprimary education and many elementary schools include a kindergarten, or "K" level, within their regular school sequence.

In 1867, an Act of Congress founded the original U.S. Department of Education, the closest equivalent to a ministry of education in other countries. Its main function, then as now, is to collect data and oversee the condition and progress of education and provide support for special programs in the field of education.

2. Administration and Funding

Most of the funds for public education in the United States come from the taxation of real property by the local school districts and from various taxes, such as the income tax, imposed by communities and states. By contrast, the majority of funds for non-public education come from tuition paid by parents. In 1983, about $215.4 billion was expended on public and non-public education in all schools from pre-primary through graduate school.[1] The federal government helps support special

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programs, such as programs for exceptional students, bilingual education, and projects for the improvement of education, although funding patterns and allocations vary from year to year.

3. School Types

About 90% of school-aged children attend public school, while the remainder attend non-public institutions run by religious organizations or private associations. Science programs in the non-public sector do not significantly differ from those taught elsewhere. At the elementary level, general or integrated science, consisting mainly of biological and physical sciences, are emphasized, although the actual time devoted to instruction is significantly less than that devoted to the teaching of reading, mathematics, and social studies. At the lower and upper secondary levels, the programs are more commonly grounded in study of specific science domains. Contents and sequence of science courses are similar in most types of schools, with the exception of a small number of fundamentalist religious schools. Most secondary schools are considered to be "comprehensive" schools. Larger school districts have develped specialized schools, the majority of which contain voactional/technical programs.

4. External Examinations

Terminal uniform examinations are not mandated nationwide as they are in many other nations. In 1983, however, 40 states had minimum-competency examinations administered to public school children at designated grades in the K-12 sequence. Most of these states planned to use these examinations as one criterion for high school graduation,[2] and some states had already instituted this requirement.

Apart from state mandates, some local school districts use their own competency examinations with their student population at periodic intervals and adopt local regulations for grade promotion and graduation.

5. National Plans

Because of state and regional differences, it is difficult to describe a national program of science education in the United States. There are exceptions to almost any general statement about education in the U.S. Despite the diversity found in United States educational systems, apparent similarities in schooling and learning experiences do exist.

The decentralized system of education in the United States precludes direct supervision or control of most aspects of school instruction by the federal government. State revenues accounted for the principal share of aid to schools,[3] followed by local revenues and finally, federal support.

6. Pressures

The cry for national reform, for "excellence in education," is the most often cited goal of the 1980s regarding present and future needs in the field. Widely publicized status reports from influential public and

private sectors in the early part of the decade described steadily declining test scores of students in mathematics and reading over the previous 10 years. Many urged a greater emphasis on basic required skills, suggested criteria for grade promotions at all levels and urged the reinstatement of tougher graduation requirements. It was generally felt that the alarming shortages of well trained teachers in math and science contributed to the problem, particularly at the secondary level.

Added to this was growing public awareness of the erosion of the nation's technological leadership in the international marketplace. In part, this was perceived to be the result of poorly prepared students entering the workforce at the secondary and post-secondary levels.

These forces created the demand for more stringent educational guidelines. In science education, the effect has been felt in the doubling of high school graduation requirements in science coursework (from one year to two years) in approximately 25 states. Many of the remaining states were considering similar requirements. State revenues have also been directed toward teacher preparation, certification, and retention, particularly in the areas of math and science at the secondary level.[4]

Section 2: Aims and Objectives of Science Education

1. Aims

Goals of science education for the 1980s focus on making all students "scientifically literate". In order to achieve this end, curricula have been developed using the following criteria:[5]

1. Academic Knowledge of Science and Technology: this knowledge should encompass the factual information within the disciplines and the technological ramifications of science research. However, while most organizations and agencies affiliated with science education agree in principle to the inclusion of technology, less consensus exists upon the contents of such in on-going science programs. Additionally, many experts feel a separate course offering should be developed for non-academic students.
2. Practice and Application of Science Process Skills: these skills involve developing laboratory aptitudes (e.g., observation, measurement, classification, data collection) and cognitive abilities used to objectively examine physical phenomena (e.g., hypothesis formulation, data analysis and interpretation, verification, generalization).
3. Application of Knowledge and Skills in Daily Life and Society: the relevancy of learning science should extend beyond the subject domain to areas that affect the course of personal and societal development (for example, ramifications or implications of science in personal health, career choices, the environment, technology). An "informed citizenry" that can make prudent decisions on issues having significant scientific/technological dimensions is one important outcome of this.

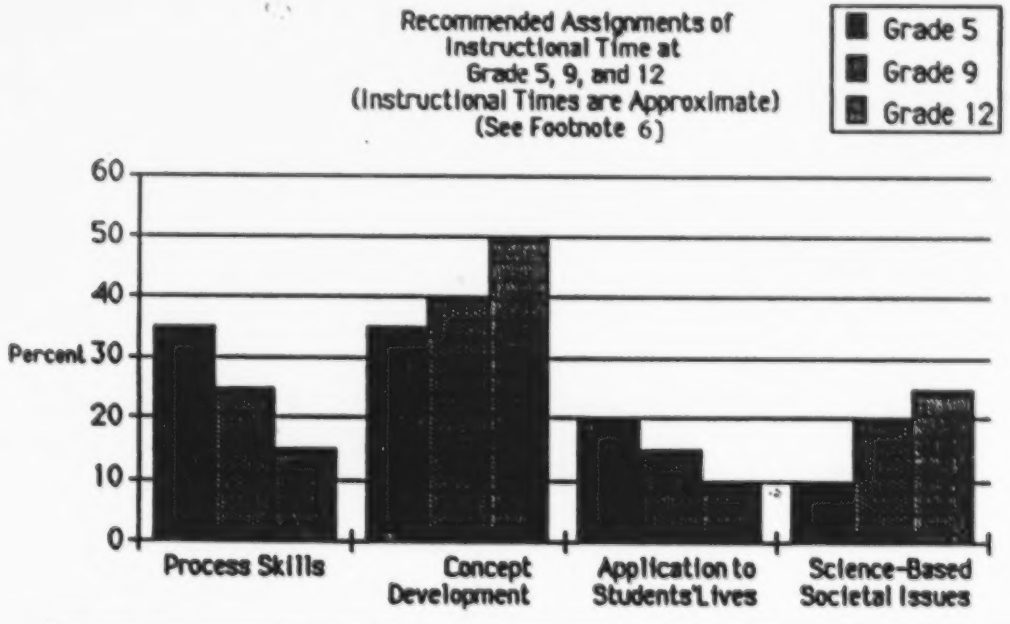
These broadly described goals for science education in the 1980s

were categorized by the National Science Teachers Association into four general blocks:

- Process Skills
- Concept Development
- Application to the students' personal lives
- Science-Based Societal Issues

Instruction at all levels should encompass all four categories. However, the recommended emphasis of each cluster varied with respect to grade level. The figure below shows recommended allotment of instructional time at grades 5, 9, and 12.[6]

FIGURE 1



Section 3: Curriculum Development and Content

1. Curriculum Content

Two common patterns for science education are shown in Figure 2. An important difference prevails between the organization of science in United States secondary schools when compared to many other national educational systems. In many countries, the various sciences are studied each year of the secondary school. In the United States, a different science is studied each year. For example, a common pattern is to have earth science in the 9th grade, biology in the 10th grade, chemistry in the 11th grade and physics in the 12th grade.

FIGURE 2

Common Patterns of Science Curriculum in the U.S.A.

<table>
<tr><th>Age</th><th>I</th><th>II</th><th>Grade</th></tr>
<tr><td>17</td><td>Physics I</td><td>Advanced Placement or Honors: Biology, Chemistry, Physics</td><td>12</td></tr>
<tr><td>16</td><td>Chemistry I</td><td>Physics I</td><td>11</td></tr>
<tr><td>15</td><td>Biology I</td><td>Chemistry I</td><td>10</td></tr>
<tr><td>14</td><td>Physical Science</td><td>Earth Science or Biology</td><td>9</td></tr>
<tr><td>13</td><td>Earth and Space</td><td rowspan="2">General or Integrated Science</td><td>8</td></tr>
<tr><td>12</td><td>Life Science</td><td>7</td></tr>
<tr><td>11</td><td rowspan="6">Elementary School Science</td><td rowspan="6"></td><td>6</td></tr>
<tr><td>10</td><td>5</td></tr>
<tr><td>9</td><td>4</td></tr>
<tr><td>8</td><td>3</td></tr>
<tr><td>7</td><td>2</td></tr>
<tr><td>6</td><td>1</td></tr>
<tr><td>5</td><td></td><td></td><td>K</td></tr>
</table>

- SECONDARY LEVEL -

- ELEMENTARY LEVEL -

Optional Secondary Courses: Astronomy, Ecology, Environmental Science, Marine Biology, Oceanography, Genetics, Zoology, Physiology, Laboratory Techniques....

• Upper Elementary Level - Grade 5

Science programs are not standardized to a great extent at this level in U.S. schools. Content may include units from any one, or all of the basic or applied sciences. Frequently, however, the content is grouped by broadly conceptual themes, such as "Circulation" or "Systems of the Body," which reflect a focus on one of the physical or biological/ environmental fields.

Process skills, particularly those associated with basic laboratory experiences, such as classification, observation, and measurement of phenomena, are considered essential elements of science instruction. These are introduced and reinforced through "hands-on" activities, in which students use these skills to draw tentative conclusions about the objects being examined. As reflected in the curricula for Population 1, acquisition of practical skills, along with attainment of knowledge and comprehension of factual content, are the areas of greatest concern in the science curricula.

• Lower Secondary Level - Grade 9

At the lower secondary level, courses in general science, physical science, earth science, and biological science are often offered. Less frequently, a unified or integrated science course is offered.

Laboratory skills are highly stressed in planned science curricula at this level. Attendant process skills related to scientific methodology and data gathering are regarded with equal importance, and included within the science curricula.

• Upper Secondary Level - Grade 12

Consensus with respect to the content of science programs at the upper secondary level is greater than that at the lower secondary level. The science curriculum at the terminal year of secondary school is usually a full year sequence in one branch of science. Most often, the science offered is physics, but many schools also include a second year of biology or chemistry. Since many states require no more than two years of upper secondary science credit for graduation, the numbers of students enrolled in science courses at grade 12 are much fewer than for Populations 1 or 2.

The curriculum ratings indicated a high level of emphasis on process skills for this grade level. A prime reason for this is state guidelines, which generally require a block of instructional time in student-centered laboratory work. Although apportionment differs, at least one or two periods of laboratory work per week are recommended in experimental activity. Experiments undertaken by students often focus directly upon reinforcing their understanding of the factual contents of science rather than reflecting the inquiry nature of science. The cognitive skills that were most heavily emphasized in the curricular ratings were in the areas of knowledge acquisition of known or accepted phenomena (terminology, laws, concepts, procedures).

2. Curriculum Development

There is no standard method for developing science curricula in the United States; rather, several approaches are commonly employed.

Dedicated professionals--teachers and supervisors--work diligently developing science curricula for their school systems, often adapting state or city guidelines to the needs of local student bodies. However, from the late 1950s through the early 1970s, major curriculum development projects funded by government agencies, such as the National Science Foundation, spawned reforms in the approaches to instructional development. Wayne Welch, in reviewing these projects, suggested that the efforts had the following characteristics:

a. Although projects were often identified with prominent scientists, almost all involved the cooperation of a large number of scientists, teachers and administrators.
b. Many of the projects were classroom tested, but the results did not necessarily influence subsequent versions in any significant manner.
c. Mechanisms such as summer institutes and short-term workshops were set up to familiarize teachers and administrators with the new curriculum materials.
d. Commercial publishers were selected to print and market the materials.

Since the intense activity in science curriculum development in the 1960s and early 1970s, there has been a sharp diminution of funded curriculum projects. Teachers, science educators, and scientists continue to generate science curriculum materials, but they must frequently rely on their own resources for these endeavors. School systems continue to produce science materials as well. Similar curricular materials are used throughout the United States. Science curriculum materials are often written by teams of teachers, science educators, scientists, editors, and media specialists. The science curriculum materials are then produced and distributed by commercial publishers. Because publishers are anxious to enhance sales, they tend to publish text materials similar to those that have been selected by teachers and school systems in the past. There is a hesitancy to depart radically from that which has proven market value; hence, the materials produced by different publishers are often quite similar. The textbook tradition is so deeply entrenched that even the process-oriented science programs of the 1960s and 1970s eventually generated textbooks for classroom use. Since 90% to 95% of the teachers use textbooks as a major educational resource 90% of the time, there is a tendency toward homogeneity in the experiences students have in the United States.[7]

More attention is being focused on developing science materials for special populations, such as the educable mentally handicapped, the gifted, or in particular fields, such as environmental and computer science. However, major agencies like the National Science Foundation reduced their support of science curriculum development in the late 1970s and early 1980s.

3. Curriculum Implementation

In most districts, the text and/or curriculum materials "are usually selected by individual teachers and teacher committees. Principals and supervisors are sometimes involved in text selection,"[8] but parents, students, and school board members are seldom involved. In some states, a text-adoption procedure is used which requires that books purchased

with state funds must be selected from the state's approved list.

Despite the fact that the choice of the text is usually theirs, "many teachers criticize the text they are using as having too difficult a reading level for many students."[9] The decentralized system of education provides considerable latitude for teachers to modify the curriculum for their students and communities. Because of this freedom, articulation of science curricula between grades, within schools and between different schools of the same grade level, is a problem area. Not surprisingly, within any classroom, "the science taught and the way it is taught is dependent primarily on what the individual teacher believes, know, and does."[10] Implementation of new curricular materials can only take place at the local level and then only if teachers are prepared and willing to use them. Supervisors and admninstrators can be very influential in facilitating changes and supporting and monitoring their continuance.

Section 4: Teacher Education

1. Pre-service Education

Teacher certification guidelines are established by the states and a different course of collegiate study is generally prescribed for elementary school accreditation and secondary school accreditation. Preservice teacher education is carried out in many of the 3,134 colleges, universities, and branch campuses across the nation. Classroom teachers are trained by undergraduate and graduate institutions. The teacher education institutions are concerned that their graduates be recruited by school systems, and many try to prepare the types of teachers that school systems say they need. This feedback process is one of the factors that leads to some uniformity. About 2.5 million teachers work in elementary and secondary schools, although the numbers of college students expressing an intention to teach have significantly declined from 1973. In 1981, 108,000 Baccalaureate degrees were awarded in education as compared to 194,000 awarded in 1973.[11] Almost all public school teachers are college graduates. Over 99% have at least a Bachelor's degree, 49.3% have a Master's degree or a six-year diploma, and 0.3% a Doctor's degree.[12]

In many states, there are two steps or levels of certification:

1. provisional (temporary or probationary) and
2. permanent (life) certificates

A general pattern of requirements for the second level of certification is a Master's degree (or 30 semester hours beyond the Bachelor's degree) and several years of teaching experience.

2. Pre-service Science Education

Elementary school teachers generally perceive themselves as less well-qualified to teach science than mathematics, reading, and social studies.[13] This may be because they usually have had very little science in their academic work. To be certified to teach at the elementary level, a student must complete a four-year Baccalaureate program; some

colleges offer elementary education degree programs that lead to state certification, while others require students to pursue a broad liberal arts background augmented with special courses in education. Many state requirements for elementary certification have the following pattern:

Baccalaureate degree, including

a. 24 semester hours of education courses
b. one semester of supervised student teaching in an elementary school

States seldom require that elementary school teachers take science courses before being certified.

Secondary school science teachers usually have considerably stronger preparation in the sciences. For example, in the State of New York a minimum of 36 semester hours of college level work in the sciences is required for certification to teach science.[14] Many science teachers have a more substantial background in the academic sciences. The general pattern of preparation for secondary science teachers is:

Baccalaureate degree, including

a. at least 36 semester hours of science,
b. 12 semester hours of education courses,
c. one semester of supervised student teaching in science in a secondary school

A few states have separate certification requirements for middle/junior high school teachers, but the vast majority have only the elementary (N-6 or N-8) and secondary (7-12 or 9-12) level certificates.

3. In-service Science Education

In-service education is sometimes undertaken by the individual teacher without institutional support. It may take the form of independent study, work on the curricula of the school, special workshops, short institutes and graduate work at universities. Local school systems also provide opportunities, such as conferences and workshops, to help teachers update their knowledge. The institutes, workshops, and conferences sponsored by the National Science Foundation were a significant contribution to in-service education during the 1970s. Forty-seven percent of the high school science teachers, 32% of the junior high school teachers, and 12% of the teachers of grades four through six had participated in at least one of these activities.[15] A recent survey showed that more than 40% of all science, mathematics and social studies teachers had taken a course for college credit during the preceding year.[16]

The salary structure of teachers is low when compared to those of other professions in the United States. The national average for a beginning teacher was $14,000 in 1984-1985, while the average salary of all teachers was $23,546. In the mid-1980s, teacher salaries began to rise relative to the rate of inflation after losing ground between 1974-1983. Actual purchasing power from teacher's salaries in 1985 was about equal to that of 1973, the peak for teachers across the nation. To alleviate teacher shortages, some states and large municipalities implemented higher starting salaries to bring them up to a more competitive level. In 1985, for example, New Jersey adopted a statewide minimum of $18,500. These gains, however, were not representative of the national

wage scale for most entry-level teaching positions.[17]

There is a growing concern that teacher shortages, particularly in mathematics and science, will reach crisis proportions in the 1990s as states raise their academic standards for high school graduation. To attract and keep bright, able graduates in the teaching profession, a number of strategies have been instituted by state education agencies. Scholarships and fellowships in math and science education have been offered to deserving undergraduate and graduate degree candidates.

Regulations regarding in-service training of teachers are not uniform, although a small proportion of cities and school districts have established guidelines regarding the number and content of in-service experiences for teachers.

Among the initiatives undertaken in the 1980s by separate states, 20 reported that some form of program for the professional development of teachers had been enacted or approved, while 21 others were contemplating such programs. Incentives to teachers to continue professional growth in the form of career ladders and Master Teacher awards were implemented by 6 states, and proposed for consideration by 24 others.[18] In the vast majority of school systems however, no requirement or incentive currently exists to expand one's knowledge, background or skills once a permanent license has been obtained.

Section 5: Science Teaching

1. Teaching Patterns

Science in the elementary school is usually taught by the generalist classroom teacher in the self-contained classroom. This teacher has the responsibility for instruction in reading, mathematics, social studies, science, art, music, and other subjects. Most often, the teacher does not have a strong backround in any of the sciences. Relatively little time is devoted to science in the elementary schools. It is reported that the average number of minutes a day spent teaching science (K-3) is 17. In grades four to six, an average of 28 minutes a day is devoted to science.[19]

Beginning with the middle or junior high school, instruction becomes "departmentalized." This means that instruction is provided by a teacher specifically certified in a field, such as biology, earth science, chemistry, or physics.

In the middle/junior high years, science is becoming a required full year course in each of the grades. In some schools and states, junior high science is still a "half-year course." In these cases, students study health, industrial arts, etc., in the remainder of the school year.

At the high school level, science curriculum also has a lower priority than subjects such as English and social studies. Since 1983, most states have moved toward increasing graduation requirements. In 1989, at least 24 states will require two years of science, as compared to four for English and three for social studies.[20]

2. Teaching Methods

The following teaching and learning practices characterize science

education in the elementary and secondary schools in the United States.[21]

1. "Hands-on" or manipulative materials were used in 48% of classes at least once a week.[22] Science educators are concerned about science classes where manipulative materials are never or seldom used and that the amount of "hands-on" experiences will be further reduced by declines in school budgets.
2. The textbook continues to occupy a central role in science instruction. Textbooks are used in virtually all science classes with approximately one-third of the classes using multiple texts.[23]
3. Lecture and discussion are the predominant techniques used in science classes.[24]
4. Alternate activities such as library work, student projects, field trips, and guest speakers are other approaches to science instruction.[25]
5. Films, filmstrips, film loops, slides, tapes, and records are used. Calculators, computers, television, and other technological developments are also influencing science instruction.[26]
6. In reviewing the three studies of science education, a committee of the National Science Teachers Association concluded that the "teacher is the key" to good science instruction, and that more support must be given to the teacher to make good science instruction possible.[27]

From data collected in the SISS, it appears that the field trip is becoming an "endangered species." At all levels, the majority of teachers (68% at grade 5, 89% at grade 9, and 93% at grade 12 physics) reported that they rarely or never schedule field trips for their science classes. The "lecture," "question-answer," and "same assignment" modes form their teaching strategy. Such a pattern is easily interpreted as a "textbook dominant," approach. On the same instrument (SISS Teacher Questionnaire), all teachers reported that they "occasionally or frequently" present science demonstrations (74.0% in grade 5, 85% in grade 9, and 93% in grade 12 physics). "Students performing laboratory experiments" was done frequently in 19% of the grade 5 classes, 55% of the grade 9 classes, and 70% of the physics classes. Perhaps, a number of U.S. science teachers have evolved an eclectic approach, incorporating the demonstration and laboratory with the textbook, lecture, and question/answer format.

3. Student Assessment

As there are no national examinations and only one state-administered science examination system (New York), the schools and teachers have the major responsibility for developing an appropriate assessment plan.

The following information was collected with the SISS Teacher Questionnaire. At all levels, teachers reported that they rarely or never used "standardized tests produced outside the school" (74% at grade five, 66% at grade nine, and 64% for physics courses). The most common assessment procedure was "teacher-made objective (short answer) tests." This was reported to be used "frequently" by 56% of the grade five

teachers, 72% of the grade nine teachers, and 62% of the physics teachers. In contrast, only 14%-17% of these teachers used "teacher-made essay tests (requiring at least one paragraph of writing)." The "use of performance on homework assignments" in assessing students was a "frequent" or "occasional" practice reported by the majority of the teachers sampled (76% at grade five, 80% at grade nine, 85% in physics). Consistent with the demonstration/laboratory approach cited earlier, these teachers reported "frequent use of performance on laboratory exercises and/or projects" (24% at grade five, 50% at grade nine, and 66% in physics) in assessment.

4. Assistance and Supervision

About 75% of schools with grades 10 through 12 have science department chairs who supervise science instruction. More than half of all elementary and junior high schools have no such supervision. At the elementary school level almost 20% of the school principals do not feel well qualified to supervise science instruction.[28]

In U.S. schools, science teachers are provided very little direct assistance and/or supervision. From the SISS School Questionnaire results, it is clear that laboratory assistants or technicians are almost non-existent. The vast majority of schools (91% at grade 9 and 87% at grade 12) reported that "none" of these personnel were employed at their schools. Few principals are trained in science, and they are unable to provide specific guidelines or recommendations. Larger schools and districts employ science supervisors, consultants, or directors. These specialists have few if any teaching responsibilities. The scope of their duties ranges widely, but could include equipment requisition, hiring and evaluation of teachers, working with teachers on curriculum revision, student program development, and the development of programs for student assessment. In most schools, an experienced science teacher is appointed as a science department head, chair, or team leader. These people have primary responsibilities as classroom teachers with one or more periods "released" to coordinate departmental activities. With the small amount of time allotted, much of what they do is order equipment and supplies, requisition textbooks and lab books, and schedule classes and labs. Approximately 27% of elementary schools, 45% of lower secondary schools, and 75% of upper secondary schools have department heads in science.[29]

At the state level, the State Education Departments employ specialists in science education for advice and assistance to the science programs in science education. In a few states, there are regional "educational service centers," which provide some of these services. The monitoring or "inspection" role of these state/regional science specialists is minor.

5. Professional Associations

The major professional association for science teachers is the National Science Teachers Association (NSTA). The NSTA schedules a national meeting and three regional meetings each year at which science teachers can present and learn about local, state, and national

projects, activities and developments and can view the latest in science textbooks and equipment. Published through the NSTA are three journals: Science and Children (for elementary and middle school teachers), The Science Teacher (for secondary teachers), and the Journal of College Science Teaching. Further, the NSTA publishes a wide variety of materials for teachers.

There are several more specialized organizations affiliated with NSTA: the Association for the Education of Teachers in Science (AETS), the Council for Elementary Science International (CESI), the Council of State Science Supervisors (CSSS), the National Association for Research in Science Teaching (NARST), the National Science Supervisors Association (NSSA), and the Society for College Science Teachers (SCST). Science Education and the Journal of Research in Science Teaching are important research journals.

Additionally, many states have active associations for science teachers with state and regional meetings, journals, etc. Many science teachers at the secondary level also are active in one or more of the following: the National Association for Biology Teachers (NABT), the American Association of Physics Teachers (AAPT), and the Division of Chemical Education of the American Chemical Society, etc. These specialist teacher groups are affiliated with their respective scientific organizations, such as the American Institute for Biological Science (AIBS), American Chemical Society (ACS). Again, journals and conferences are the main methods of communication among members.

Section 6: Other Topics

1. Laboratories

Laboratory facilities for science are usually not provided at the elementary level. Only about nine percent of elementary science classes in grades four through six are conducted in labs and special science rooms. Most students (54%) are taught science in rooms containing "portable science materials," while over one third learn in rooms that contain no special facilities whatever.[30] There is a greater emphasis upon laboratory experiences at the secondary level. Forty-three percent of upper secondary level students taking science have some aspect of laboratory work or projects incorporated fairly often, or frequently, in their coursework.[31] Allocation and upkeep of special laboratory rooms for science instruction, at all grade levels, is heavily dependent upon space availability and perception of need by the individual school districts or educational systems.

2. Equipment and Supplies

A frequent complaint of U.S. science teachers is lack of functioning, modern equipment and an adequate supply of materials to conduct high quality, activity-oriented science programs. The underlying problem is a lack of money in the school budget for such items. Relatively few schools have budgets specifically allocated for science equipment and supplies, although the likelihood of the existence of such

budgets increases at the higher school levels or grades. In general, more funding is allotted for the purchase of supplies than science equipment. In a national survey taken in the late 1970s, 20% of elementary, 29% of lower secondary, and 57% of upper secondary schools indicated that specific budgets were set aside for the purchase of science supplies.[52]

3. Talented Students

At the elementary and middle/junior high levels, relatively few special programs exist for students talented in science. At the high school level, many schools offer talented students the opportunity to accelerate their science program by taking the traditional 10th grade course as a 9th grader with further acceleration throughout the high school years. Their acceleration usually results in the students electing one or more of the advanced (second year) science courses. The most frequently offered advanced science course is Second Year (or Advanced Placement) Biology. Students can earn college credit for these courses, if they score high enough on the advanced placement test.

A few large schools, counties, and/or states have established special schools for students talented in science. Perhaps the most well-known of these is the Bronx High School for Science in the New York City School System. More recently, the North Carolina School of Science and Mathematics was established. Many summer science programs are offered to students with special abilities. These are often supported by the National Science Foundation (NSF), private or public corporations, universities, or other funding sources. Most of these are short-term projects which focus on specialized topics and suffer from a lack of "follow-through."

A number of scholarships and competitions are available for talented science students. The Westinghouse Talent Search and National Merit Scholarships reward outstanding science students. The winners are awarded scholarships for college study. A more recent development is the National Science Olympiad. A series of individual and team events assessing knowledge of science facts, concepts, processes, skills, and applications are scheduled. This is a competition among teams from schools representing each state.

4. Special Groups

Many programs have been developed to provide activities and curricula for students who are mentally, visually, physically, or hearing handicapped. These exemplary programs help students learn science through the senses or abilities they possess. Many of these projects are supported by the U.S. Department of Education and other agencies. The products of the programs (activities and curricula) have been found to be useful for other groups of students as well.

5. Computers

Computers have become familiar objects in American schools. About 82% of all elementary, 93.1% of all junior high schools, and 94% of

all senior high schools were using microcomputers by the fall of 1984.[33]

The data collected in the SISS Teacher Questionnaire (in the spring of 1983) were very similar, indicating "access to a computer at school" in 34% of the grade 5 schools, 53% of the grade 9 schools, and 64% of the grade 12 schools.

Computer literacy programs for students as well as instructors represent its most common use, followed by drill and practice, tutorials, and simulation exercises.[34]

In science, interactive courseware has been created that extends the range of computer applications. Laboratory experiments can be conducted, for example, in which the computer can be used to measure, record and graph data as it is received from heat, light, or sound sensor probes connected to the terminal. Additional uses in science include its utilization in word processing and database management for student projects.

6. Out-of-School Science

Opportunities to pursue science interests outside the classroom are available for both secondary and elementary students. Universities, museums, planetariums, zoos, botanical gardens, science academies, and national science or science-related organizations, societies and councils sponsor programs which youngsters can attend after school or on weekends.

There are statewide and nationwide competitions in which the best students report the outcome of science research. Winners are often rewarded with college scholarships.

Institutions in the private sector also initiate programs which donate money, equipment, personnel or facilities to nurture science interest and talent in the school-aged population. Internships and mentorships are often established with laboratories and hospitals on a volunteer basis.

FOOTNOTES

1. U.S. Bureau of the Census, Statistical Abstract of the United States: 1985, (Washington, D.C.: U.S. Government Printing Office) p. 129 (No. 205).

2. National Center for Education Statistics, The Condition of Education, 1984, Vance Grant and Valena W. Plisko, Eds., (Washington, D.C.: U.S. Department of Education), p. 152.

3. U.S. Department of Education, The Nation Responds, 1984 (Washington, D.C.: U.S. Office of Documents), pp. 144-146.

4. Ibid.

5. This discussion of goals for science education is adapted from: National Science Teachers Association position statement, Science-Technology-Society: Science Education for the 1980s (Washington, D.C.: National Science Teachers Association, 1982), and Willard J. Jacobson, "Goals for Science Education," Studies in Science and Mathematics Education: An International Research Journal, vol. 1., no. 1 (New Delhi, India: National Council of Educational Research and Training, 1978), pp. 1-6.

6. National Science Teachers Association, Science-Technology-Society for the 1980s, (Washington, D.C.: National Science Teachers Association, 1982), p. 3.

7. Norris C. Harms and Robert E. Yager, eds., What Research Says to the Science Teacher, vol. 3 (Washington D.C.: National Science Teachers Association, 1981), p. 115.

8. James V. DeRose, J. David Lockard, and Lester G. Paldy, "The Teacher is the Key: A Report of Three NSF Studies," in What are the Needs in Precollege Science, Mathematics, and Social Science Education? Views from the Field, ed. National Science Foundation (Washington D.C.: U.S. Government Printing Office, 1980), p. 44.

9. Ibid.

10. Ibid., p. 49.

11. American Chemical Society, Tomorrow - The Report of the Task Force for the Study of Chemistry Education in the United States, (Washington, D.C., American Chemical Society, 1984), p. 1.

12. U.S. Bureau of the Census, Statistical Abstract of the United States: 1985, (Washington, D.C.: U.S. Government Printing Office) p. 140 (No. 225).

13. Iris R. Weiss, Report of the 1977 National Survey of Science, Mathematics and Social Studies Education, (Washington, D.C.: U.S. Government Printing Office, 1978, p. 142.

14. The University of the State of New York, Teacher's Certificates (Albany, New York: The State Education Department, 1973), p. 10.

15. Iris R. Weiss, Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education, (Washington, D.C.: U.S. Government Printing Office, 1978), p. 69.

16. Ibid., p. 140.

17. Jonathan Friendly, "After Lag, Teachers Start to Catch Up on Pay," New York Times, Vol. CXXXIV, (Aug. 31, 1985), pp. 1 and 5.

18. U.S. Department of Education, The Nation Responds, 1984 (Washington, D.C.: U.S. Office of Documents), pp. 144-146.

19. Iris R. Weiss, Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education (Washington D.C.: U.S. Government Printing Office, 1978), p. 51.

20 U.S. Department of Education, The Nation Responds, 1984 (Washington, D.C.: U.S. Office of Documents), pp. 144-146.

21. The major source for these statements is: Iris R. Weiss, Report of the 1977 National Survey of Science, Mathematics and Social Studies Education, (Washington, D.C.: U.S. Government Printing Office), 1978.

22. Ibid., p. 107.

23. Ibid., p. 89.

24. Ibid., p. 106.

25. Ibid., p. 103.

26. Ibid., p. 112.

27. James V. DeRose, J. David Lockard, and Lester G. Paldy, "The Teacher is the Key: A Report of Three NSF Studies," in What are the Needs in Precollege Science, Mathematics, and Social Science Education? Views from the Field, ed. National Science Foundation (Washington D,C,: U.S. Government Printing Office, 1980), p. 49.

28. Iris R. Weiss, Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education (Washington D.C.: U.S. Government Printing Office, 1978), p. 51.

29. Unpublished results from Second International Science Study, New York: Teachers College, Columbia University.

30. Iris R. Weiss, Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education, (Washington, D.C.: U.S. Government Printing Office, 1978), p. 129.

31. The National Science Board Commission on PreCollege Education in Mathematics, Science and Technology, Science and Engineering Education: Data and Information, (Washington, D.C.: Office of Scientific Engineering Personnel and Education, 1982), p. 19.

32. Ibid., p. 15.

33. National Center for Education Statistics, Condition of Education, 1985, Valena White Plisko and Joyce D. Stern, eds. (Washington, D.C.: U.S. Department of Education), errata sheet, Table 1.14.

34. A Report by the Office of Technology Assessment, Informational Technology and its Impact on American Education, (Washington, D.C.: U.S. Government Printing Office, November, 1982), p. 143.